

Exercise	1.1	1.2	1.3	Total
100%	4	4	4	12
Points				

**Name:**  
**Stellar Astrophysics**  
Homework - Lecture 14 - Energy production  
**Due date: October 27**

## 1 Nuclear processes

1. What temperature would be required for two protons to collide if quantum mechanical tunneling is neglected? Assume that nuclei having velocities ten times the root-mean-square (rms) value for the Maxwell-Boltzmann distribution can overcome the Coulomb barrier<sup>1</sup>. Compare your answer with the estimated central temperature of the Sun.
2. Use the Maxwell-Boltzmann distribution function

$$n_v = n \left( \frac{m}{2\pi kT} \right)^{3/2} e^{-mv^2/2kT} 4\pi v^2 \quad (1)$$

to calculate the ratio of the number of protons having velocities ten times the rms value to those moving at the rms velocity.

3. Assuming (incorrectly) that the Sun is pure hydrogen, estimate the number of hydrogen nuclei in the Sun. Could there be enough protons moving with a speed ten times the rms value to account for the Sun's luminosity?

Look into Sections 8.1 in Carroll & Ostlie in case you have to refresh your knowledge about the Maxwell-Boltzmann distribution.

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<sup>1</sup>the separation between the charges can be assumed to be  $r \simeq 2 \text{ fm} = 2 \times 10^{-13} \text{ cm}$